October 2020

VISUALIZATION OF AUTHORSHIP PATTERN AND RESEARCH COLLABORATIVE MEASURES IN DEFENCE SCIENCE JOURNAL: A SCIENTOMETRIC STUDY

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The present study deals with authorship pattern and collaborative measures in Defence Science Journal with a sample of 426 articles published in 5 volumes during the period 2015-2019. Articles of Defence Science Journal have been referred for data collection and MS-Excel for interpretation of the data.The indicators of collaboration investigated for the data are Degree of Collaboration(DC), Collaborative Index(CI), Co-authorship Network, Collaborative Coefficient(CC) and Modified Collaborative Coefficient (MCC). It was found from the study thatmaximum CC and MCC was 0.68 and 0.69 successively recorded in the year 2019. It is concluded thatthe contributions in this journal from India are slightly more than those from the other countries.

Keywords: Scientometric analysis; Authorship pattern; Coefficient Collaboration; Co-authorship Network; Modified Coefficient Collaboration; VOSviewer.

Introduction

Scientometric technique since its growth in scientific research literature has gained significance in Library and Information Science field. It deals with various aspects of publications and helps to formulate policies.[1]

Scientometrics, a branch of science was first defined in 1969 by two Russian scholars. Scientometrics investigate and study science processesand deals with quantitative aspect of research among various types of publications.[2]Scientometrics is "the study of the measurement of scientific and technological progress"[3]andit may be applied to any discipline to find out its tendency and growth of literature.[4]

Collaboration allows for effective communication by sharing of competence and other resources.[5] Research collaboration is the collective working of researchers towards the

commongoal of producing new scientific knowledge.[6] Collaborative Measures of collaboration show the pattern towards multiple authorships in a discipline, various studies utilize the mean number of authors per paper, termed as Collaborative Index[7] and the proportion of multiple authored papers, called Degree of Collaboration (DC)[8] as a measure of the quality of collaboration in a discipline.

Literature Review

Sudarsana & Baba (2019) did study on "scientometric analysis of global nuclear fuel" during 2000 to 2017. In their study indicated that half of the publications 4166 were published during 2011 to 2017 and consequently the year 2017 had the absolute best number of publications 679 and the most imperative developments in fuel research are from USA, France, South Korea and Germany.[9]

Verma et al. (2019) conducted study on "authorship and collaboration pattern of the 'Researchers World: Journal of Arts, Science and Commerce" during 2010 to 2017. In their study demonstrated that a total 662 articles were published and highest number of articles 108 (16.31%) were published within the year 2017 and highest 2.24 collaboration index was recorded within the year 2010 and the overall average of collaboration index was 1.92. The highest CC and MCC was 0.43 and 0.45 respectively recorded within the year 2010. Out of 662 articles, the most extreme 386 publications were co-authorship index while 276 publications were single author index.[10]

Yadav (2019) directed study on "authorship and collaboration pattern in SRELS Journal of Information Management" during 2008 to 2017. In their study a total 578 articles were published. 196 articles were published by single author and rest 386 articles were published by multiple authors. Study also show that the typical collaboration index is 1.86, average collaboration coefficient is 0.36, average degree of collaboration is 0.66, average relative rate of growth is 0.32 and average doubling time is 3.40 during 2008-2017.[11]

Singh (2017) examines "authorship pattern and collaboration coefficient of India in Biotechnology" research during 2001 to 2016. In their study a total 18918 articles were collected from the Scopus database. Study found that the average number of authors per article for India was 4.92 and collaboration Co-efficient was 0.63 for India. Multi-authored articles were higher in average in the correlation of single-authored articles. The relative growth rate was decreasing, and the average activity index of India was 91.78 during the study period.[12]

Garg & Dwivedi (2014) directed study on entitle “collaboration pattern in the discipline of Japanese encephalitis”. This study was based on 2074 articles indexed by Science Citation Index which is published by various countries in the discipline of Japanese encephalitis during 1991-2010. In theirinvestigation the Collaboration was extremely high which is 478 (23%) out of all the distributed articles and 478 (23%) was with global collaboration. USA is the most collaborating nation among all the nations. The examination also indicates that collaboration was increased four times during 2001-2010 as compared to 1991-2000 andthe highest six institutions from India were highly collaborative among all the 17 institutions.[13]

Objectives of study

This study has the following objectives:

- To study year volume and issue-wise distribution of the articles published during 2015 to 2019
- To know the authorship pattern of the articles published
- To classify the Degree of authors collaboration and Collaboration Index
- To recognize Collaborative co-efficient and Modified co-efficient
- To detect Doubling time and relative growth rate
- To categorize Co-authorship Network

Methodology

The current investigation depends on the publication in Defence Science Journal (DSJ) during the time of the examination from 2015-2019. Quantitative analyses of data applying scientometric techniques using various scientometric methods are employed DRDO Publication website is usedfor collecting the data. For study 426 research papers have been used for data collection. In this present study following patterns are identified; CC (Collaboration Co-efficient), MCC (Modified Collaboration Coefficient), Co-authorship Network, RGR (Relative Growth Rate) and Dt (Doublig Time) of publications and the formulas were used with appropriate tables. The data were analyzed and tabulated with the help of MS-Excel and the VOSviewer software was used for visualization of Co-authorship network.

Data Analysis and Interpretation

Year, Volume and Issue-wise contribution of paper

Table 1- Year, Volume and Issue-wise contribution of paper

Year	Vol. No.	Issue-wise No. of Contribution						Total	%age of Contribution
		1	2	3	4	5	6		
2015	65	11	12	12	12	12	12	71	16.66
2016	66	12	15	12	16	15	16	86	20.18
2017	67	17	15	14	22	15	13	96	22.53
2018	68	15	15	13	13	15	13	84	19.71
2019	69	14	15	16	15	17	12	89	20.89
Grand total		69	72	67	78	74	66	426	100

Table 1 reflects the no. of articles published during the period 2015 to 2019. This table also shows the year wise, volume wise distribution of the articles and the percentage of the contribution in each year. From the given table, it is clear that year 2017 has highest no. of articles (96) with highest percentage (22.53%) and year 2015 has lowest no. of articles (71) with lowest percentage (16.66%). Overall, from the total 426 articles, issue no. 4 has published highest articles i.e. 78 and issue no. 6 has published the lowest articles i.e. 66 published. The range of the articles published in all issues is 12 to 22.

Relative Growth Rate and Doubling Time of Publication

Relative Growth Rate (RGR) is a measure to study the increase in number[14] of articles over the period and Doubling Time (DT) records[15] the time in which quantity doubles in size or value.[16] The RGR and DTcan be calculatedby the below formula[17]:

$$RGR = \frac{W2-W1}{T2-T1}$$

Where,

RGR = Growth Rate over the certain period of thetime,

W1 = Log (natural log of the initial number of e-contributions)

W2 = Log (natural log of the final number of e-contributions)

T1 = unit of initial time

T2 = unit of final time

There is a direct equivalence between the relative growth rate and doubling.[18] if the number of articlesdoubled during a given period, the difference between logarithms[19] of numbers at the

beginning and end of this period must be logarithms of number 2. If natural logarithms are used this difference has a value of 0.693. In this manner the relating doubling time for each specific period of interval[20] and for articles can be determined by the formula.

Doubling time $=\frac{0.693}{\bar{R}}$

Where $\bar{R}$= Relative Growth Rate

Table 2- Relative Growth Rate and Doubling Time of Publication

Year	Total Paper	Cumulative sum	W1	W2	RGR	Mean R= ΣR/N	Dt	Mean ΣDt/N
2015	71	71	0	4.26	0		0	
2016	86	157	4.26	5.05	0.79		0.88	
2017	96	253	5.05	5.53	0.48	0.36	1.44	1.54
2018	84	337	5.53	5.82	0.29		2.39	
2019	89	426	5.82	6.05	0.23		3.01	

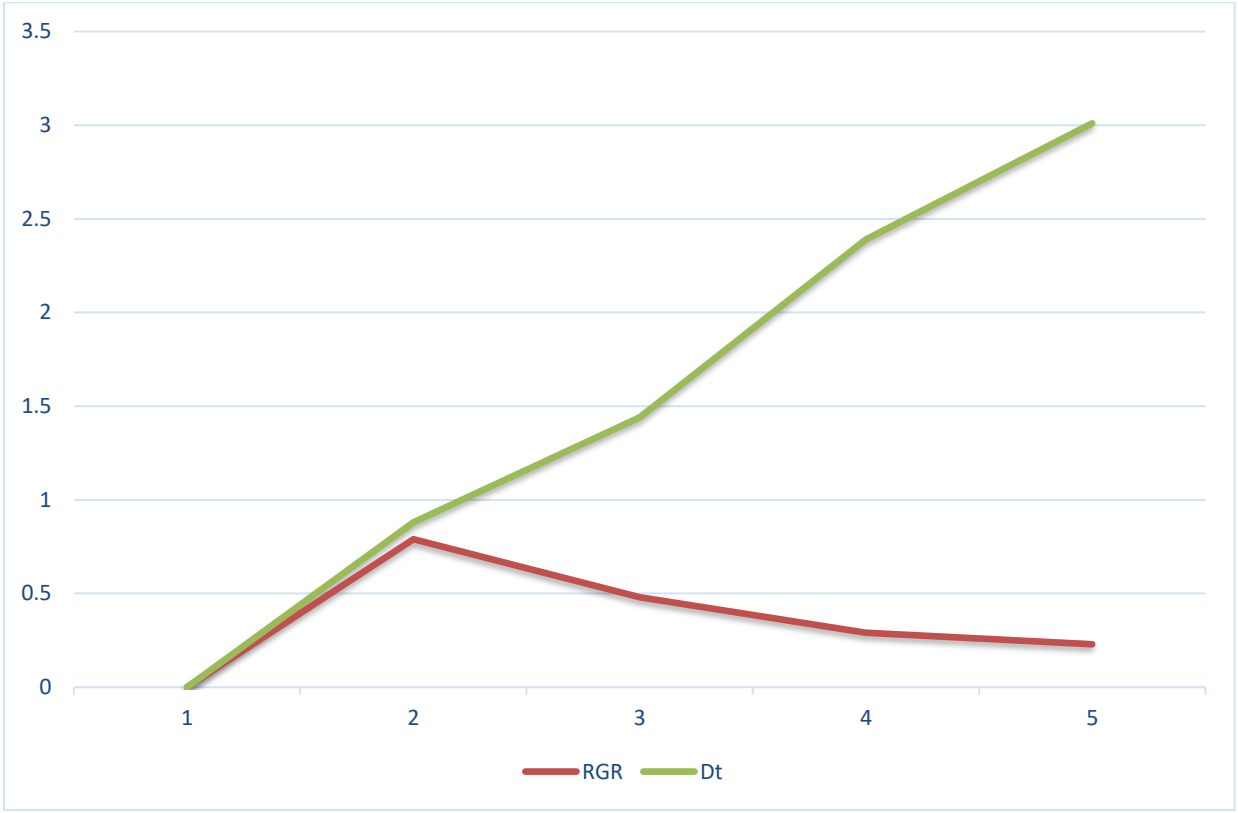

Fig.1 - Relative Growth Rate and Doubling Time of Publication

Table 2 and Figure 1shows that the RGR and Dt during the research. According to RGR and Doubling time model, the growth rate of publication has been calculated. Highest RGR (0.79) was identified in the year 2016, followed by 0.48 in the year 2017. And the highest Dt was identified in the year 2019 i.e. 3.01, followed by 2.39in the year 2018.Inthe year 2015 RGR and Dt was zero. The Mean of relative growth rate for the periods of 2015 to 2019 was 0.36 and the mean of doubling time was 1.54.

Authorship Pattern

Table 3- Authorship Pattern

Year	Volume No.	Single Author	Two Author	Three Author	Four Author	Five Author	More Than Five Author	No. of Publication
2015	65	2	28	19	8	7	7	71
2016	66	3	23	26	15	10	9	86
2017	67	3	30	23	20	12	8	96
2018	68	3	24	26	12	13	6	84
2019	69	2	15	31	25	7	9	89
Total		13	120	125	80	49	39	426
%age of Author		3.05	28.16	29.34	18.77	11.5	9.15	100

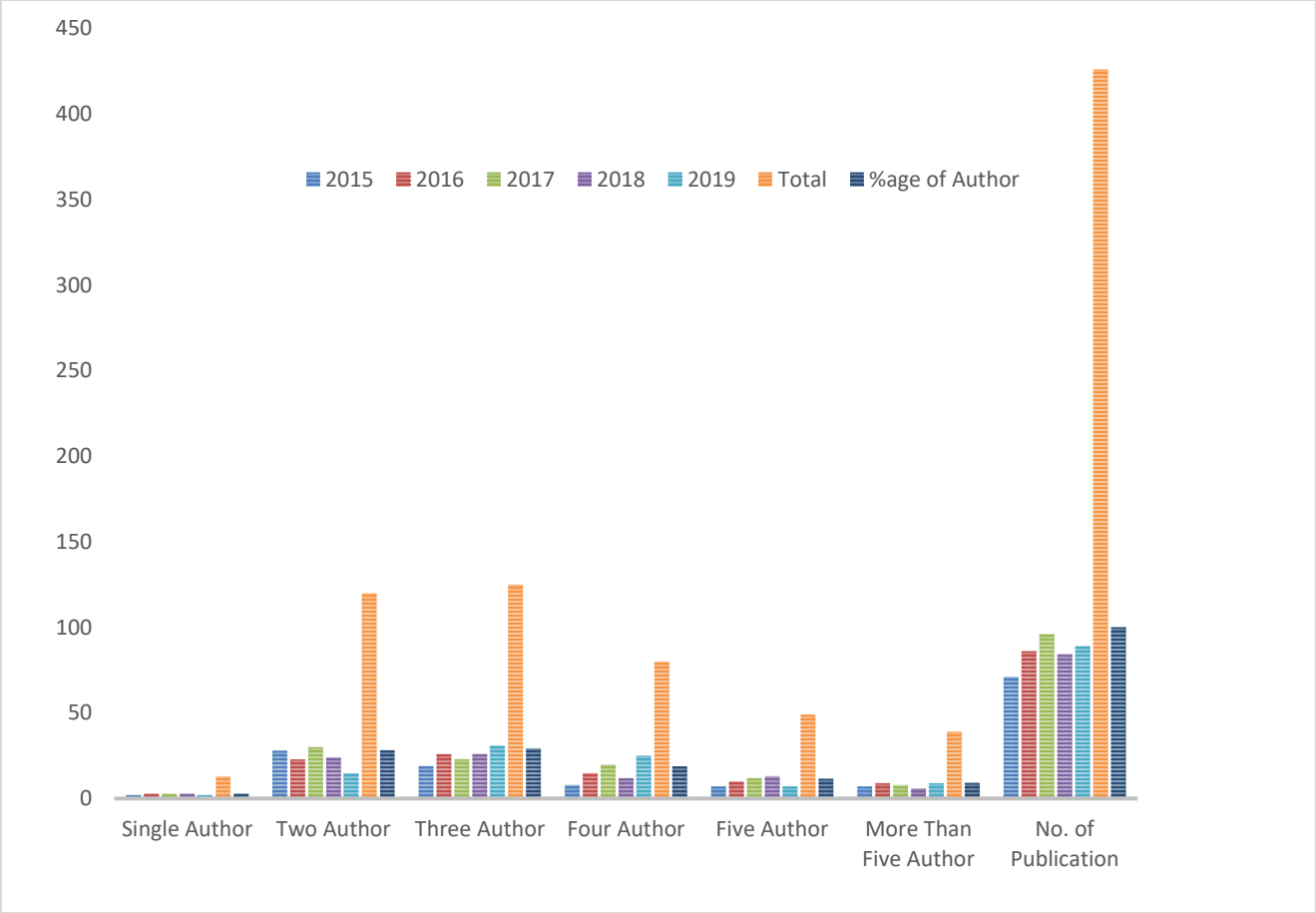

Fig. 2- Authorship Pattern

Table 3 and figure 2 describe the authorship pattern of articles during the period under study and found that the total number of articles is 426, in which there are 13 (3.05%) single author publications, 120 (28.16%) two authors publications, 125 (29.34%) three authors publications, 80 (18.77%) four authors publications, 49 (11.5%) five authors publication and 39 (9.15%) more than five authors publications. In the year 2017 maximum number of authors published their articles (96). Single author contributions are 3.5%, which is very low, whereas 96.94% are multiple author contributions which are very high. It shows that article publication trend was towards the multiple author approach.

Collaboration Measures

Degree of Collaboration

Table 4- Degree of Collaboration

Year	Single Authored Publication (Ns)	Multi Authored Publication (Nm)	Nm+Ns	Degree of Collaboration [DC=Nm/(Nm+Ns)
2015	2	69	71	0.97
2016	3	83	86	0.96
2017	3	93	96	0.96
2018	3	81	84	0.96
2019	2	87	89	0.97
Total	13	413	426	0.96

To determine degree of collaboration, the below formula was used. This was suggested by Subramanyam.

$$DC = \frac{Nm}{Nm+Ns}$$

Where,

DC is the degree of collaboration,

Nm is number of multi authored papers, and

Ns is the number of single authored papers.

$$DC = \frac{413}{426} = 0.96$$

Table 4 shows Degree of Collaboration and it can be observed that average value of DC is 0.96. Under the study the degree of collaboration shows its influence on multi authorship.

Co-Authorship Network

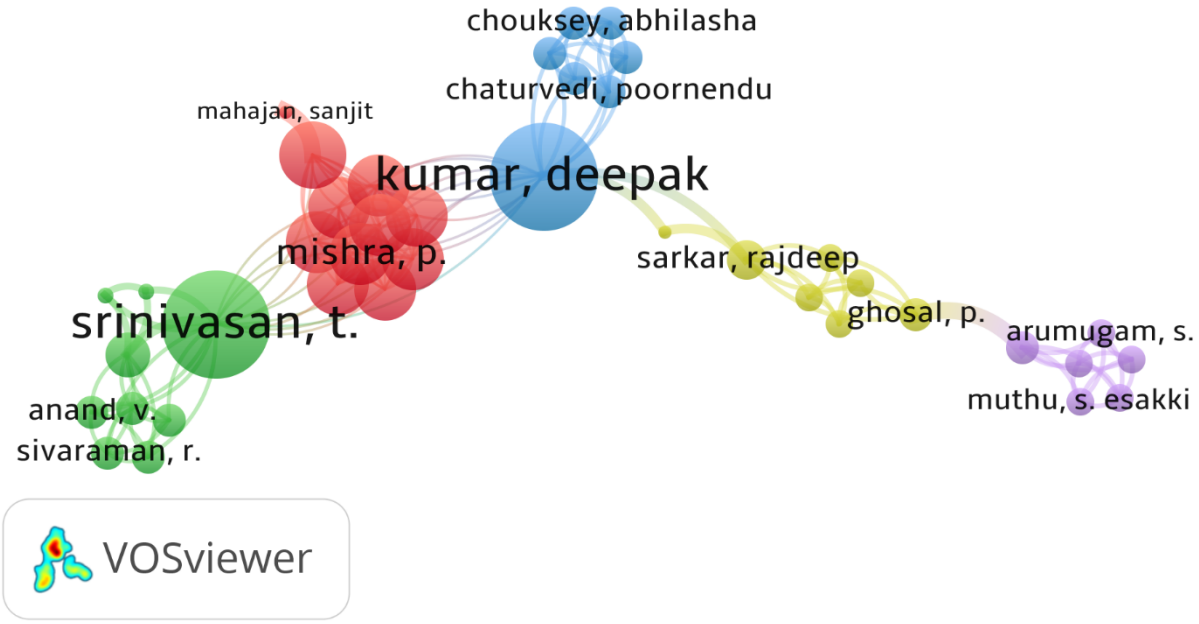

Fig. 3 - Co-authorship network

Figure 4 display the visualization of the Co-authorship network. Network was analyses on the basis of bibliographical data downloaded from dimension (https://app.dimensions.ai)[21]and after that networks was created with the help of VOSviewer software (https://www.vosviewer.com/)[22]. The network contains 40 nodes, 148 co-authorship links and 5 clusters. The software analyzes manually defined criteria which is minimum 1 document and citations of an author. Figure the node symbol is represent to author, size is activity of the author, and the curved line between the two authors is represent collaboration relationship between them. The software separates these 41 authors into 5 clusters which from 148 links with a total link strength of 24.50. Author Kumar, Deepak and Sirnivasan, t. both authors have total 19 links with other authors are the leading authors who produced maximum paper in collaboration.

Collaborative Index

Collaborative Index measures mean number of authors per paper. To calculated collaborative index, the below formula was used by Elango and Rajendran. [23]

$$CI = \frac{\textbf{Total number of authors}}{\textbf{Total joint papers}}$$

Table 6- Collaborative Index

Year	Multi Authored Papers	Total Authors of Multi Authored Papers	CI
2015	69	223	3.23
2016	83	296	3.56
2017	93	336	3.61
2018	81	279	3.44
2019	87	321	3.68
Total	413	1455	3.52

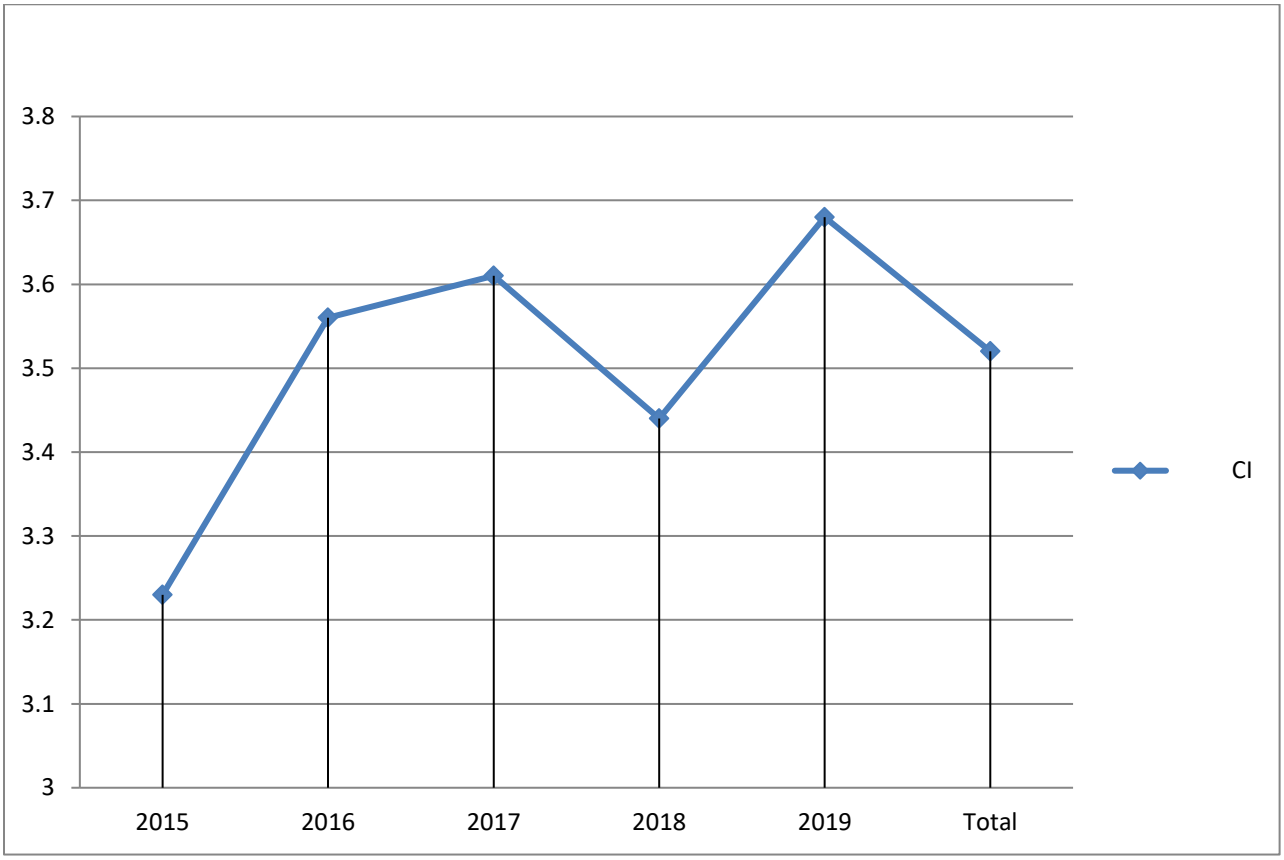

Fig. 4 - Collaborative Index

Collaborative Index is presented in table 6 and figure 4.It can be observed that maximum CI 3.68 was recorded in the year 2019 and minimum CI 3.23 was recorded in the year 2015. The average collaborative Index was 3.52 during the period of study.

Collaboration coefficient and Modified collaboration coefficient

Ajiferuke, Burell and Tague have shown the mean number of authors per publications. According to them the part of multi authorship, as measures of degree of collaboration in a discipline, is inadequate.[24]In this way; they proposed a measure combining some of the benefits of both measures into a term known as Collaborative Coefficient (CC).

The formula for Collaborative Coefficient (CC) is given by Ajiferuke et.al.[25]

$$CC = 1 - \frac{\sum_{j=1}^{k}(1/j)fj}{N}$$

Where,

fj= number of j-authors research publications published in a discipline during a certain period.

N = total number of research papers published in a discipline during a certain period

k = greatest number of authors per paper in a discipline.

$$\text{Calculation of Collaborative Coefficient} = 1 - \frac{f1+\left(\frac{1}{2}\right)f2+\left(\frac{1}{2}\right)f3+\cdots+\left(\frac{1}{k}\right)fk}{N}$$

Based on the data in table 7Collaborative Coefficient for the year 2019 has been calculated as

$$CC = 1 - \frac{(2 + \left(\frac{1}{2}\right)X15 + \left(\frac{1}{3}\right)X\ 31 + \left(\frac{1}{4}\right)X\ 25 + \left(\frac{1}{5}\right)X\ 7 + \left(\frac{1}{6}\right)X\ 6 + \left(\frac{1}{7}\right)X\ 2 + \left(\frac{1}{13}\right)X\ 1}{89}$$

$$= 1 - \frac{2+7.5+10.33+6.25+1.4+1+0.28+0.07}{89}$$

$$= 1 - \frac{28.83}{89}$$

$$= 0.68$$

Similarly, all the data for CC calculated by this formula.

Modified collaboration coefficient (MCC)

The formula for calculation of MCC is given by Sarvanur and Srikanth[26]

$$MCC = \frac{A}{A-1}\left\{1 - \frac{\sum_{j=1}^{A}(1/j)fj}{N}\right\}$$

The data in table 7 MCC for the year 2019 has been calculated as

$$MCC = \frac{89}{88}\{1 - \frac{(2 + \left(\frac{1}{2}\right)X15 + \left(\frac{1}{3}\right)X\ 31 + \left(\frac{1}{4}\right)X\ 25 + \left(\frac{1}{5}\right)X\ 7 + \left(\frac{1}{6}\right)X\ 6 + \left(\frac{1}{7}\right)X\ 2 + \left(\frac{1}{13}\right)X\ 1}{89}\}$$

$$=1.01\{1 - \frac{28.83}{89}\}$$

$$= 1.01\ X\ 0.68$$

$$= 0.69$$

Similarly, the value of MCC for all the relating year has been calculated.

Table 7- Collaboration coefficient and Modified collaboration coefficient

Year	Single Author	Two Author	Three Author	Four Author	Five Author	More than Five author	Total	CC	MCC
2015	2	28	19	8	7	7	71	0.63	0.63
2016	3	23	26	15	10	9	86	0.65	0.66
2017	3	30	23	20	12	8	96	0.65	0.66
2018	3	24	26	12	13	6	84	0.65	0.66
2019	2	15	31	25	7	9	89	0.68	0.69
Total	13	120	125	80	49	39	426	0.65	0.65

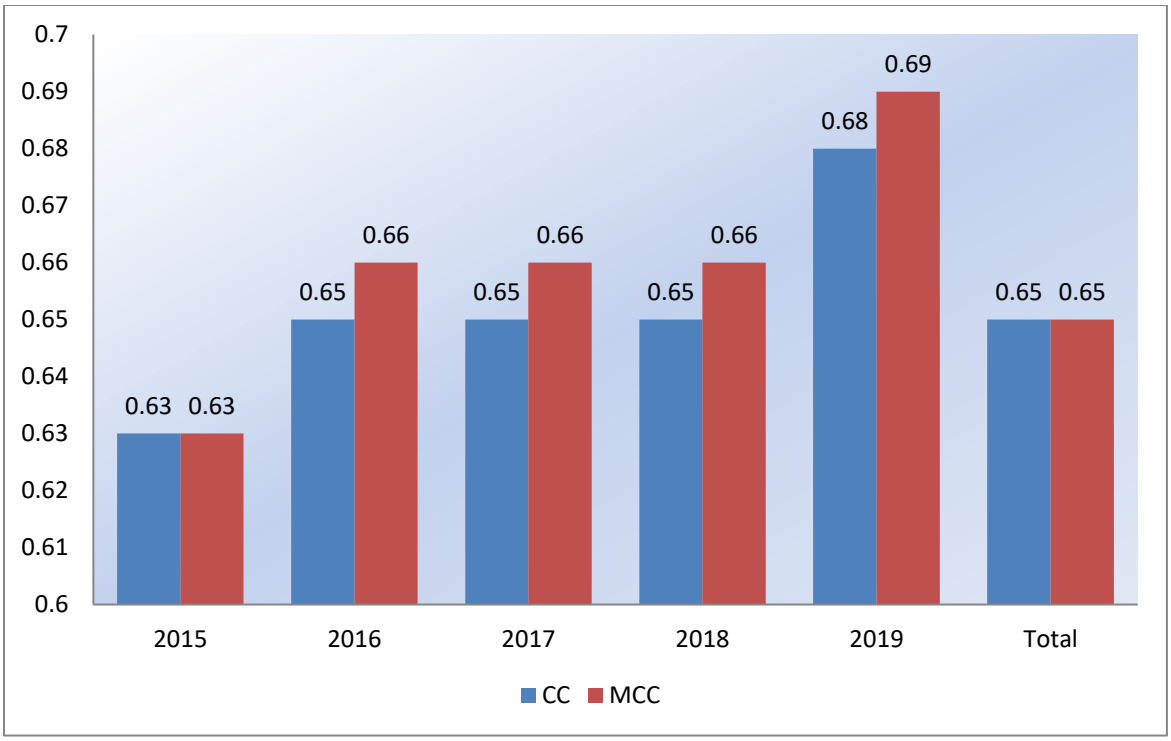

Fig. 5 - Collaboration coefficient and Modified collaboration coefficient

Table 7 and figure 5 shows the Collaboration coefficient and Modified collaboration coefficient from the study. Highest CC and MCC was 0.68 and 0.69 successively listed in the year 2019. The total Collaboration coefficient (CC) and Modified collaboration coefficient (MCC) was 0.65.

Table 8- Country-wise contribution

Country	No. of contributors	%	Rank
India	1162	79.16	1
China	125	8.52	2
Turkey	25	1.7	3
Czech Republic	23	1.57	4
Israel	20	1.36	5
Serbia	16	1.08	6
Korea	16	0.88	7
Iran	13	0.88	7
Egypt	9	0.61	8
Poland	9	0.61	8
Brazil	8	0.54	9
Russia	7	0.47	10
Mexico	5	0.34	11
Malaysia	5	0.34	11
Spain	5	0.34	11
Macedonia	5	0.34	11
USA	4	0.27	12
Italy	2	0.13	13
Romania	2	0.13	13
Azerbaijan	2	0.13	13
Finland	1	0.06	14
Germany	1	0.06	14
Belgium	1	0.06	14
Vietnam	1	0.06	14
Albania	1	0.06	14
Total	**1468**	**100**	

Figure 6: Country-wise contribution

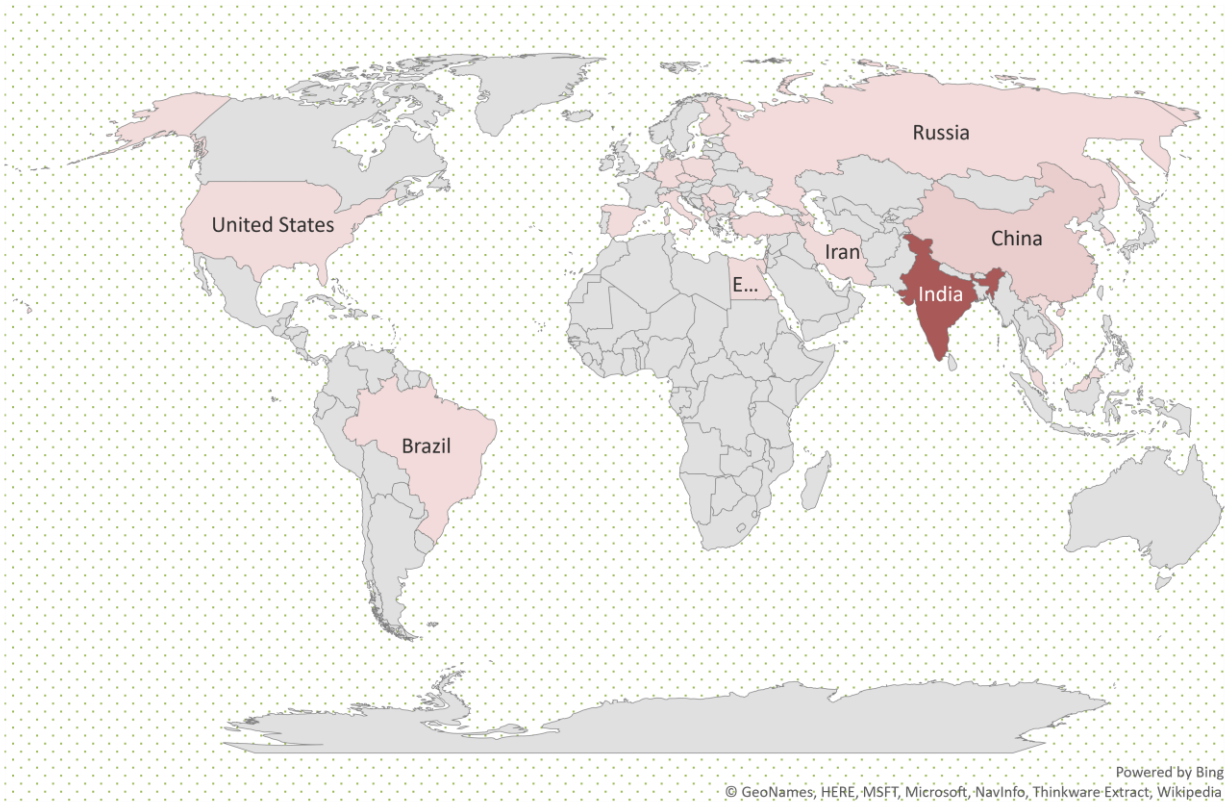

Figure 6 display Country-wise contribution[27]of 1468 authors published 426 articles from different countries. It is analyzed from table 8 and figure 5 that the highest number of contributors 1162(79.16%) belongs to India with 1st rank and 125 (8.52%) contributors are from China, 25 (1.7%) contributors are from Turkey and 23 (1.57%) contributors are from Czech Republic with 2nd, 3rd and 4th rank. From Other countries like Finland, Germany, Belgium, Vietnam and Albania only one author contributed in DSJ with the 14th rank.

Findings

The Defence science journal published 426 articles during the period (2015-2019) of study. Year, volume and issue wise contribution of papers, RGR and Dt, authorship pattern of articles, Degree of Collaboration, Collaborative Index, CAI, CC and MCC are such as:

- ✓ It has been found that year 2017 has highest no. of articles 96 (22.53%) and year 2015 has lowest no. of articles 71 (16.66%).Overall, from the total 426 articles, issue no. 4 has highest articles 78 published and in issue no. 6 has lowest articles 66 published.

- ✓ Relative Growth Rate (RGR) of an article gradually decreases correspondingly the value of Doubling time of the articles (Dt) gradually increases. The maximum RGR and Doubling time was listed in the year 2016 and 2019.
- ✓ It is analyzed by authorship pattern of papers that 13 (3.05%) of single author, 120 (28.16%) of two author, 125 (29.34%) of three author, 80 (18.77%) of four author, 49 (11.5%) of five author and 39 (9.15%) of more than five author paperwere published during the study period.
- ✓ The overall degree of collaboration was 0.96 only 13 articles were single authored publications, whereas 413 articles were multi authored publications.
- ✓ Author Kumar, Deepak and Sirnivasan, t. are the leading authors who produced maximum paper in collaboration.
- ✓ Highest CC and MCC was 0.68 and 0.69 successively listed in the year 2019.
- ✓ There was 3.52 average collaborative Index during the period of study.
- ✓ It is observed that highest number of contributors belong to India with 1162 (79.16%) out of 1468, followed by China with 125 (8.52%)

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